REMARKS

The Examiner objects to the disclosure noting an informality on page 3, line 23 of the specification. Correction has been made. Withdrawal of the rejection is requested.

The Examiner rejects claim 1 under 35 U.S.C. 112, first paragraph as allegedly failing to comply with the enablement requirement. The Examiner contends that the claim covers "every conceivable structure for achieving the property of echo cancellation while the specification discloses at most only those means known to the inventor," citing *In re Hyatt*. *In re Hyatt* dealt with a single means claim. Claim 1 is not a means-plus-function claim. Moreover, claim 1 does not cover every conceivable structure for achieving echo cancellation. Withdrawal of this objection is therefore respectfully requested.

Claims 11, 33, and 42 stand rejected under 35 U.S.C. 112, first paragraph as allegedly failing to comply enablement requirement. The Examiner contends that the Hermitian symmetry "is applicable to matrices not vectors." Applicants disagree. The Examiner's attention is directed to page 9 of the specification, in particular equation (2) and the supporting text, which specifically defines Hermitian symmetry of a vector X_i. This definition of Hermitian symmetry of a vector is a standard definition commonly used in the technical literature and known to those skilled in the art. The Examiner's attention is directed, for example, to the technical paper "High-Speed Full-Duplex Echo Cancellation for Discrete Multitone Modulation," by Minnie Ho et al., Information Systems Lab, Stanford University 0-7803-0950-2/93, 1993, IEEE, page 772. A copy is

attached to this amendment. The last line in column 1 of this article makes reference to "forming Hermitian symmetric data symbol vectors, each with *N* complex-valued...." Withdrawal of the Examiner's nonenablement rejection is respectfully requested.

Nearly all of the claims stand rejected for anticipation under 35 U.S.C. 102(b) based upon commonly-assigned U.S. patent 5,793,801 to Fertner. This rejection is respectfully traversed.

Fertner relates to both echo canceling <u>in the time domain</u> and to timing recovery. The Examiner's attention is directed to equations (1)-(4) which established that the echo canceller operates in the time domain. The vector X_n in equation (3) includes previously-transmitted symbols corresponding to the input signal in the time domain as indicated by the lower case vector values $(x_n \ldots x_{n-(N-1)})$ vector X_n is multiplied by a vector of coefficients C_n that corresponds to the channel estimate. In other words, the vector C_n is the sampled echo impulse response of the transmission channel at time instance t_n, where one symbol corresponds to one sampling instant. The product of C_n^T and X_n in equation (5) is the echo estimate depicted by the <u>time domain</u> scalar y_n. As is clearly stated in column 9, lines 30-32, the "echo canceller 36 (implemented as an adaptive digital filter) essentially estimates the echo impulse response of the echo path <u>in the time domain</u>" (emphasis added). This statement directly contradicts the Examiner's contention that Fertner discloses an echo canceller completely canceling a received echo signal in the frequency domain. The Examiner confuses statements in the Fertner Abstract that certain

calculations are performed in the frequency domain with what is recited in independent claim 1.

The Examiner's attention is directed to Fertner's echo canceller 36 shown in Figure 4. The adaptive filtering is performed on time domain signals x_n to produce an echo estimate y_n also in the time domain, as shown in equation (5), $y_n = C_n^T X_n$. Again, equations (2) and (3) both show a series of time domain values. Fertner therefore does not disclose the "second electronic circuitry configured to remove in the frequency domain, the estimated echo signal in the frequency domain from the received signal in the frequency domain" recited in claim 1.

Frequency domain operations in Fertner relate to two operations. First, the filter coefficients C_n are updated in the frequency domain using a time domain error as shown in equation 6. Second, each spectral coefficient has a baseband frequency component corresponding to the echo and an aliased frequency component. Fertner treats each spectral filter coefficient of the echo transfer function as the sum of a baseband component and an aliased component. Aliased components in the echo impulse response are specifically identified and compensated for in the frequency domain. This frequency domain compensation for aliasing permits accurate reconstruction (rather than approximation) of a sampled signal in situations where the phase of the sampling signal is adjusted.

The instant application describes on a frequency domain echo canceller that can be used in discrete mutlitone (DMT) base communications. In contrast, Fertner is focused

on ISDN-type communications over a digital subscriber line in which pulses are transmitted over the communication channel. Fertner does not address the particular problems echo signals cause in DMT communications, i.e., intersymbol interference (ISI) and inter-carrier interference (ICI). ICI is a problem in DMT communications because transmissions between DMT symbols cause transients in the received signal, which in turn, cause interference between the DMT subchannels or carriers. Because all practical physical echo path channels have memory, a received echo signal is affected by both ISI and ICI. In other words, the echo from one DMT carrier subchannel leaks into other carrier/subchannels within the current DMT symbol and the next transmitted DMT symbol.

Claim 1 recites that first electronic circuitry is configured to

> estimate the echo signals in the frequency domain using a combination of (i) a product of a first matrix of coefficients in the frequency domain and a transmitted symbol and (ii) a product of a second matrix of coefficients in the frequency domain and a previously-transmitted symbol.

Fertner does not disclose this quoted claim element. The Examiner contends on page 3 of the Office Action that Fertner discloses one matrix corresponding to filter coefficient a_v and another matrix to filter coefficient a_{v-1}, making reference to column 10, lines 29-35 and column 14, lines 36-46. Applicants respectfully submit that the Examiner has not properly applied the Fertner's teachings. The single filter coefficient a_v is a scalar (a magnitude) value. It is not even a vector. To read a "matrix of coefficients in the frequency domain" on a single scalar coefficient is unreasonable. At best, all of the

spectral filter coefficients a_v correspond to a single vector. Claim 1 requires two matrices.

The Examiner's contention that a single scaler a_n times a single sample corresponds to a matrix contradicts the meaning of the term matrix as it is used in the instant application and as would have been understood by a person of ordinary skill in this art. The second edition of Webster's New World Dictionary of the American language (copyright 1972) sets forth the following mathematical definition of matrix:

> set of numbers or terms arranged in rows and columns between parenthesis or double lines.

Clearly, the single scalar value a_n does not comport with this well-understood and accepted definition.

The Examiner also confuses the word "symbol" with the term "spectral component." The input signal x_n to the discrete Fourier transformer 82 shown in Fertner's Figure 4 corresponds to a sampled signal pulse. The sampled signal x_n is then transformed into a corresponding spectral component and is multiplied by a corresponding filter coefficient a_v. In contrast, claim 1 recites "a product of a first matrix of coefficients in the frequency domain and a transmitted <u>symbol</u>." As explained on page 9 of the instant application, "$\mathbf{X}_i$ denotes the i-th transmitted frequency domain symbol containing the N transmitted subsymbols $X_i(k)$." See equation (1). The transmitted symbol corresponds to a vector containing multiple subsymbols or samples–not just one sample.

Lacking multiple features of independent claim 1, the anticipation rejection of claim 1 and its dependent claims should be withdrawn. In addition, many of the claim 1 dependent claims recite additional features not disclosed by Fertner. For example, claim 3 recites that the "transmitted symbol and the previously-transmitted symbol are divided into real and imaginary parts before being combined with the respective matrix to reduce computational complexity." Applicants have reviewed column 8, lines 47-57 cited by the Examiner, and see no description of the quoted language. Where does this Fertner language describe reducing computational complexity?

Regarding claim 10, Applicants are uncertain what coefficients in column 8, lines 30-38 are NxN matrices, where N is a number of symbol samples. At best, the filter coefficients C_n form a single vector, and N is the length of that vector. The single column vector C_n is not an NxN matrix.

Independent claim 12 is not disclosed by Fertner for all the reasons described above except with respect to element (i) in which claim 12 recites a vector (rather than a matrix) of coefficients in the frequency domain.

Claim 18 recites a first matrix of coefficients and a second matrix of coefficients. Electronic circuitry is configured to "use a combination of (i) a product of the first matrix and a currently-transmitted symbol and (ii) a product of a second matrix and a previously-transmitted symbol to estimate an echo signal in the frequency domain." Fertner does not disclose these features. Claim 19 recites a vector of coefficients in the frequency domain and a matrix of coefficients in the frequency domain. Electronic

circuitry is configured to "use a combination of (i) a product of the vector and the currently-transmitted symbol and (ii) a product of the matrix and a <u>compensated</u>, previously-transmitted symbol to estimate an echo signal." Fertner does not disclose, for example, a product of a matrix and a "compensated, previously-transmitted symbol."

Claim 20 recites an echo canceller for "canceling an echo from a received signal in the frequency domain" that includes "circuitry configured to determine an estimate of the echo in a received signal using a frequency domain model of an echo path channel that takes into account effects of inter-carrier interference." Fertner does not describe a frequency domain model of an echo path channel that "takes into account effects of inter-carrier interference." Indeed, Fertner is directed to ISDN communications over a digital subscriber line in which modulated pulses are transmitted over a communications channel. There is no inter-carrier interference problem in ISDN type communications as there is, for example, in DMT communications. Inter-carrier interference (ICI) is <u>not</u> the same as inter-symbol interference (ISI).

Claim 30 recites a frequency domain echo canceller for "canceling an echo from a received signal in the frequency domain." As explained above, Fertner cancels an echo in the time domain. Figure 4 shows the <u>time-domain</u> echo estimate y_n subtracted from the <u>time domain</u> received signal d_n. Both d_n and y_n are clearly in the time domain as shown in equation 1 and explained in column 8. See, for example lines 21-24: "the error ε_n at the <u>time instant</u> t_n equals…" (emphasis added). Moreover, Fertner does not disclose circuitry "configured to determined an estimate of the echo in the received signal using a

frequency domain model of an echo path channel that includes the effects of inter-symbol interference <u>and inter-carrier interference</u>." As described above with respect to claim 20, the ISDN environment that Fertner is dealing with does not have to contend with inter-carrier interference.

Independent claim 35 recites "combining in the frequency domain a currently-transmitted symbol with a first vector or matrix of coefficients in the frequency domain" and "combining in the frequency domain a previously-transmitted symbol with a second matrix of coefficients in the frequency domain." For reasons already described above, these features are not disclosed in Fertner.

Lacking multiple features of each of the independent claims, Fertner does not teach the present invention. Accordingly, the Examiner's rejection is based on Fertner must be withdrawn. The application is in condition for allowance. An early notice to that effect is earnestly solicited.

Respectfully submitted,

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